WOODS HOLE OCEANOGRAPHIC INSTITUTION

Reference No. 61-16

OCEANOGRAPHIC AND UNDERWATER ACOUSTICS RESEARCH

conducted during the period
1 November 1960 - 30 April 1961

WOODS HOLE, MASSACHUSETTS

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Woods Hole, Massachusetts

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Submitted to Undersea Warfare Branch
Office of Naval Research

Under Contracts Nonr-1367(00)NR261-102 and Nonr-2129(00)NR261-104

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APPROVED FOR DISTRIBUTION Paul M. Fye

Paul M. Fye, Director

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INTRODUCTION

This is the status report for Contract Nonr-1367(00) for the period 1 November 1960 through 30 April 1961. The scope of this contract includes a broad program of research in physical oceanography, submarine geophysics (including underwater sound), and submarine geology. This scope is suggested by three exciting findings achieved during this period in as many different fields of oceanography. Dr. Voorhis, using the temperature and pitotmeter current-shear measurements from the thermistor chain has found an equatorial counter-current in the Atlantic similar to the Cromwell current of the Pacific. Miss Bunce, Mr. Parker, and others in an intensive bathymetric survey found the channel (minimum depth cir. 2000 fms.) through the Mid-Atlantic Ridge by which cold water passes from the western Atlantic basin into the eastern Atlantic, and Miss Bunce, of WHOI and Mr. Crampin of Cambridge University have successfully measured the thickness of the continental crust, 23 km to a layer having a seismic velocity of about 7.6 km/sec, under the continental shelf south of Ireland. This last result comes from seismic refraction observations made in cooperation with British scientists during CHAIN Cruise #13.

Cruising, at a minimum during this season, nevertheless has included the latter phase of CHAIN Cruise #13 to northern European waters, ATLANTIS Cruise #260 to submarine canyons on the continental shelf south of New England, to Muir Seamount, and to the ocean area southwest of Bermuda and CHAIN Cruise #17, a three-month cruise to the Romanche Trench. In addition two cruises under other contracts, one of CHAIN and the other of USS PRESERVER (ARS-8), have made the winter season seem very little different from the summer in our sea-going commitments.

Analysis of acoustical, geophysical, geological, and bioacoustical data has proceeded as rapidly as possible in competition with the sea-going program. Our progress in these areas is detailed below.

Much needed additional office and laboratory space was made available during January and February. We are making satisfactory progress at setting up a new analysis laboratory, and converting other laboratory spaces to new uses.

Digital computing techniques have been used in special computing applications in underwater acoustics at WHOI for many years, but recently we have commenced intensive application of digital data handling and computing facilities to a variety of computing, data storage, and data handling problems. Progress in these applications is described under Acoustic Instrumentation below.

Some bathymetric studies carried out recently under another contract have shown that even very narrow-beam, single-beam echo sounders simply cannot provide reliable depth sounding information where the topography is complex. In this work we have been experimenting with the inverted echo sounder, discussed below, originally developed to measure depth of the sound velocimeter. The inverted echo sounder is lowered to a position within a few feet of the bottom. The total acoustic travel time from surface to bottom may be read as the sum of the travel times from the instrument to the bottom and surface. True depth is then computed in the usual way with appropriate sound velocity data. In its present form the inverted echo sounder is suitable for mapping small areas, a few square miles, provided there is a suitable means of positioning the instrument. We have experimented with radio-acoustic navigation, and intend to experiment with vertical triangulation from the suspending ship as well.

Steady demands for new, modified, and improved instrumentation have been responded to in echo sounding, seismic profiling, and spectrum analysis, as detailed below.

REPORTS

The following technical reports have been completed during this period:

WHOI Ref. No. 60-38. Instruction Manual for Precision Graphic Recorder (PGR) by S. T. Knott and W. E. Witzell dated October 1960. Prepared under contracts Nonr-1367 and NObsr-72521. (Unclassified)

WHOI Ref. No. 60-44. Narrative of CHAIN Cruise #7 April - August 1959, dated November 1959. (Previously distributed as Technical Memo #9-59). Prepared under contracts Nonr-1367 and NObsr-72521. (Unclassified)

WHOI Ref. No. 61-7. A Telemetering Hydrophone by Willard Dow dated February 1961. Prepared under Contract Nonr-1367. (Unclassified)

PAPERS

During this period the following papers were submitted for publication:

Contribution No. 1122. Erratic Boulders from Great Meteor Seamount by Richard M. Pratt. Submitted to Deep-Sea Research. Prepared under Contract Nonr-1367.

Contribution No. 1178. Sound Scattering Spectra of Deep Scattering Layers in the Western North Atlantic Ocean by J. B. Hersey, R. H. Backus and Jessica Hellwig. Submitted to Deep-Sea Research. Prepared under NSF Grant G-9579.

Contribution No. 1181. Sound Scattering Layers and their Relation to Thermal Structure in the Strait of Gibraltar by R. Frassetto, R. H. Backus and E. E. Hays. Submitted to Deep-Sea Research. Prepared under contracts Nonr-1367 and NSF Grant G-9579.

Contribution No. 1189. Evidence of an Eastward Equatorial Undercurrent in the Atlantic from Measurements of Current Shear by A. D. Voorhis. Submitted to NATURE. Prepared under Contract Nonr-1367.

Contribution No. 1191. Some Observations of Bioluminescence in the Surface Waters of the Sea by R. H. Backus, C. S. Yentsch and A. Wing. Submitted to NATURE. Prepared under NSF Grant G-9579.

Progress Report on Environmental Studies in the Mediterranean Sea. Edited by J. B. Hersey. Submitted to the Journal of Underwater Acoustics. Prepared under contracts Nonr-1367 and NObsr-72521.

The Stranding of a Cuvier's Beaked Whale (Ziphius cavirostris) in Rhode Island, USA by W. E. Schevill and R. H. Backus. Submitted to Norwegian Whaling Gazette.

During this period the following papers were published:

WHOI Contribution No. 1066. A Comparison of Directly Measured Sound Velocities with Values Calculated from Hydrographic Data by E. Hays. Jour. Acous. Soc. of Am., Vol. 33, No. 1, pp. 85-88, January 1961. (Contracts Nonr-1367 and NObsr-72521)

WHOI Contribution No. 1070. Porpoises and the Bow-riding of Ships Underway by A. A. Fejer and R. H. Backus. NATURE, Vol. 188, No. 4752, pp. 700-703, November 26, 1960. (Contract Nonr-1367)

Theoretical Estimates of Submarine Echo to Surface Reverberation Ratio for a Deep Omni-Directional Source and Receiver by A. D. Voorhis. U. S. Navy Journal of Underwater Acoustics, Vol. 11, No. 1, January 1961. Prepared under Contract Nonr-1367. (Confidential)

TECHNICAL MEMORANDUM

The following technical memorandum pertaining to these contracts has been written during this period:

WHOI Tech. Memo #10-60. Cruise Plans for ATLANTIS Cruise #260. October - November 1960 by R. M. Pratt. Prepared under contracts Nonr-1367 and Nonr-2866 (Unclassified)

OCEANOGRAPHY

Sound Velocity Measurements in the Ocean (Dr. Hays).

Measurements of sound velocity as a function of depth were continued with 12 complete soundings from surface to bottom in the area between Bermuda and the Bahamas during CHAIN Cruise #17 in February. The following table summarizes our sound velocity measurements since the deep submergence model of the National Bureau of Standards Sound Velocimeter was introduced in 1959. This instrument was used throughout, but several depth-measuring procedures have been employed. We consider the acoustic methods to be the most accurate and convenient

Ship and Cruise #	Area	No. of Soundings	Remarks
YAMACRAW 10	Mediterranean Sea	5	Experimental
YAMACRAW 11	Tongue of the Ocean, Bahamas	4	Soundings, surface to bottom, cir 800 fms
CHAIN 7	Mediterranean Sea Atlantic	13 13	Surface to bottom, 1600 - 1800 fms.
CHAIN 11	Bermuda - Bahamas	4	Surface to bottom, 2000 - 2700 fms
CHAIN 13	North Atlantic and Norwegian Sea	22	Surface to bottom, >2000 fms

Ship and Cruise #	Area	No. of Soundings	Remarks
CHAIN 17	Bermuda - Bahamas	12	Surface to bottom >2500 fms.
ATLANTIS 260	Bermuda	10	Surface to bottom >2000 fms.

Depth determinations for measurements of the past year have been made with the inverted echo sounder designed by Mr. Dow (see below under "Acoustic Instrumentation"). The instrument has proved to be satisfactory, having the required precision and freedom from unmanageable drift which has proven to be characteristic of pressure measuring instruments known to us.

Thermistor Chain Observations and Instrumentation (Dr. Voorhis).

The thermistor chain was used to record continuously the surface thermal structure on the homeward passage of CHAIN from the Norwegian Sea in the Fall of 1960. Shown in Figure 1 is the ship's track from 4 November to 11 November on the last leg of this cruise. We are analyzing now the temperature structure of the mixed surface layer for horizontal fluctuations in temperature of 0.1°C or larger. A preliminary examination seems to indicate a predominant horizontal scale of 5 to 10 miles for such fluctuations. An attempt will be made to correlate these results with wind velocity, which was recorded continuously, and with other features of the weather encountered on the cruise.

On 19 February 1961 CHAIN departed from Bermuda for a three-month cruise to study oceanographic problems associated with the Romanche Trench and the equatorial mid-Atlantic Ridge The surface thermal structure was recorded almost continuously with the thermistor chain during the first phase of this cruise from Bermuda to Freetown, Sierra Leone. The ship's track for this phase is shown in Figure 2 At all times a continuous record was maintained of sea surface temperature, humidity, and wind speed and direction in order that these factors could be correlated with the thermal structure. In addition, approximately 40 measurements of horizontal current shear were made along the track. These measurements were made from two pitotmeters which were mounted at the top and bottom, respectively, of the

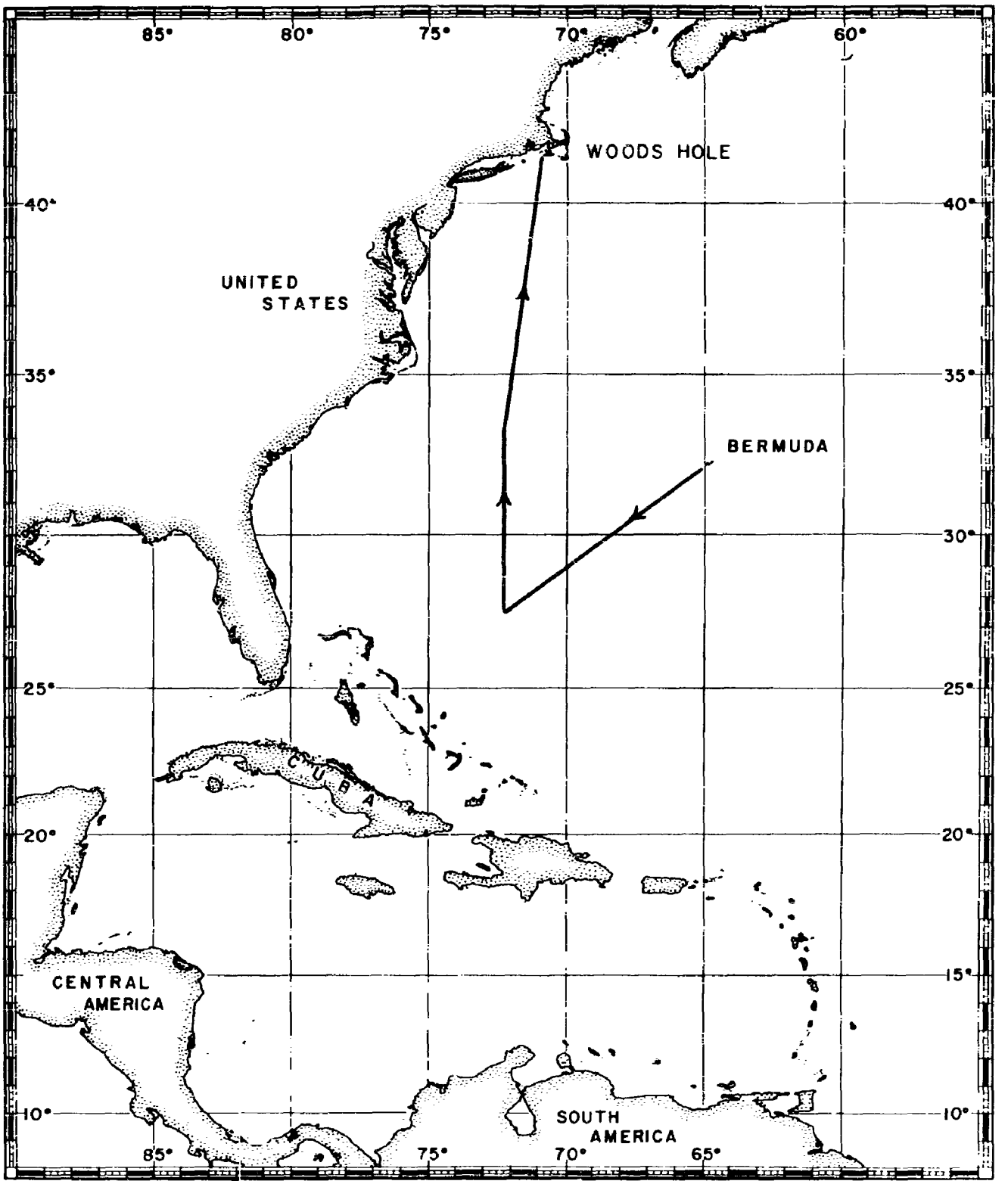

FIGURE 1. THERMISTOR CHAIN TRACK FROM 4 NOVEMBER TO 11 NOVEMBER 1960

thermistor chain. By maneuvering the ship on a box course it was possible to measure the vector difference or shear between the surface water velocity and the horizontal water velocity at a depth of 100 meters. At the equator in the area shown in Figure 2 these shear measurements immediately revealed the presence of an eastward flowing equatorial undercurrent similar to the Cromwell current in the Pacific Ocean. Shears as high as 150 cm/sec were measured. A preliminary report of these measurements has been submitted to NATURE magazine (WHOI Contribution #1189). The set of the ship indicated a westward surface current at the equator of 40 to 60 cm/sec. This means that the undercurrent at 100 meters is eastward flowing and at points as high as 100 cm/sec. The shear measurements also indicated that the southern boundary of the undercurrent lies somewhere between 1° and 2° south latitude. The temperature profiles also showed distinct changes in thermal structure in going north or south from the equator across the boundaries of the undercurrent. A complete analysis of the temperature profiles is expected to reveal considerable information about the structure of the undercurrent in the region shown in Figure 2.

Intense internal waves were observed on the steep thermocline in the equatorial region. We were able to measure the oscillatory water velocity due to these waves from speed fluctuations detected by the pitotmeter at the bottom of the thermistor chain. In addition, we expect to be able to estimate wave length and direction of propagation of the internal waves by analyzing the thermistor records taken when the ship maneuvered over a box course for our shear measurements.

ALUMINAUT (Mr. Vine and Dr. Walsh).

Work has continued on general problems associated with WHOI operation and use of a deep manned submersible.

Most conspicuous has been the partial construction of a full size wooden mock-up of ALUMINAUT (Fig. 3). This mock-up includes a fiber glass hemisphere for one end and twenty feet of the cylindrical section with internal ribs every 40 inches. The mock-up is mounted on a trailer to permit its use at Woods Hole or New London.

Already the mock-up has been very helpful in indicating what internal arrangements and what internal dimensions of benches, etc., are handiest for the crew. There have been frequent meetings with designers

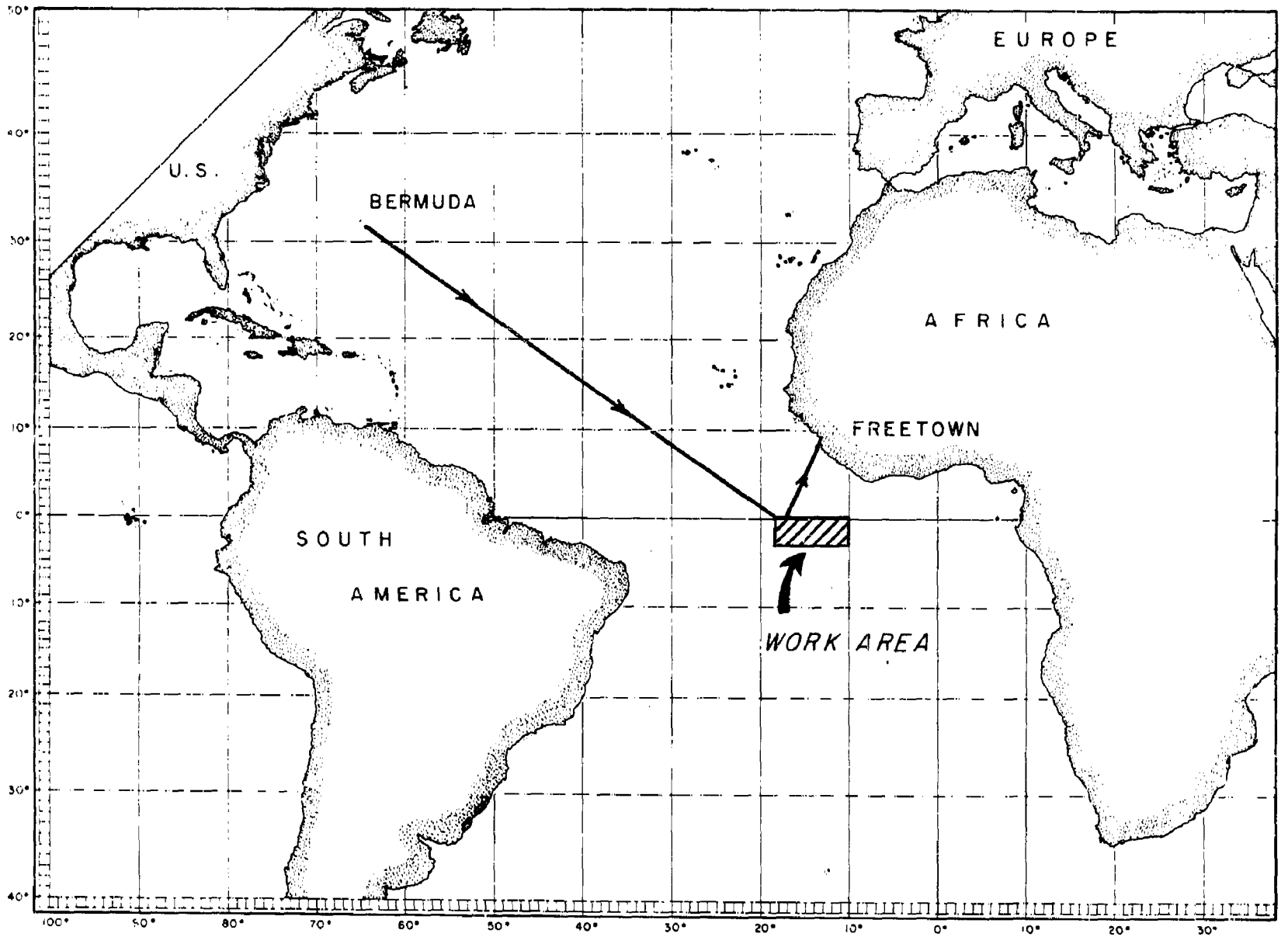

FIGURE 2. THERMISTOR CHAIN TRACK FROM 19 FEBRUARY TO 22 MARCH 1961.

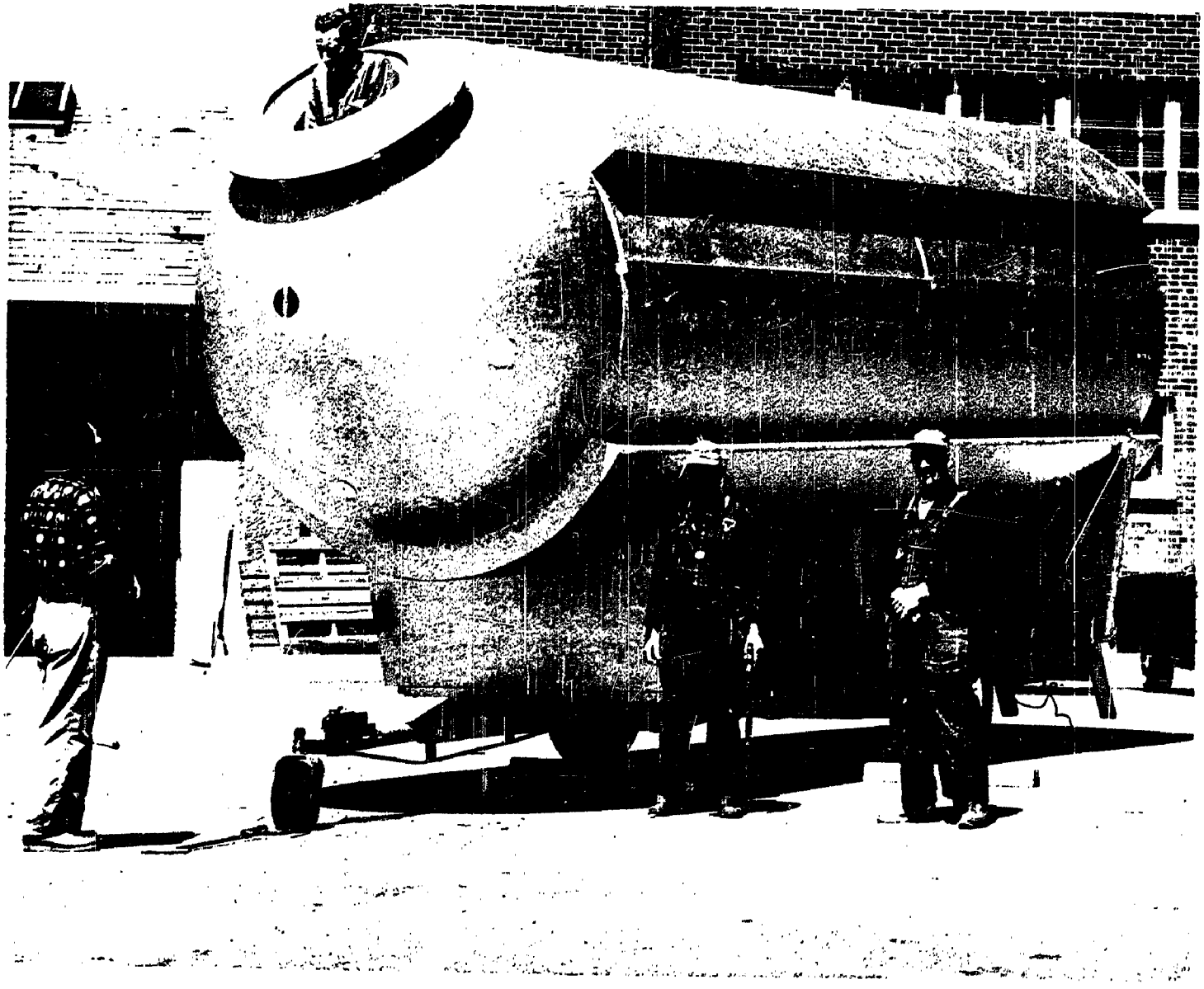

FIGURE 3. EARLY STAGE OF FULL SCALE MOCK-UP OF HALF THE ALUMINAUT.

at the Electric Boat Company and with technical engineers of companies that might construct scientific apparatus for the craft.

Dr. Joseph Walsh who has joined the staff of WHOI has concerned himself with reviewing constructional aspects of the craft that affect its ultimate strength.

We have also been doing what we can to speed contract negotiations with the Reynolds Metals Company and ONR.

SUBMARINE GEOLOGY AND GEOPHYSICS

Seismic Refraction Studies in the Western Mediterranean (Mr. Fahlquist).

Analysis of seismic refraction profiles obtained on ATLANTIS Cruise 242 (1958) and CHAIN 7 (1959) is continuing. Six of seven profiles from the 1958 cruise have been completed and the final travel time plots are now being drafted. Profile 5 (1959) has been completely analyzed and the final travel time plot has been drafted. Profiles 2, 3, 4 (1959) are still under study and should be completed by early summer.

Seismic Refraction Studies on the Continental Shelf South of Ireland (Dr. Hersey and Miss Bunce)

Analysis of the seismic refraction travel time data taken on CHAIN Cruise #13 (Tech. Memo #7-60) and on DISCOVERY has been in progress at Woods Hole and at the Department of Geodesy and Geophysics of Cambridge University Analysis has been completed through the stage of applying the necessary corrections, i.e., shot-instant time and reduction to surface of reference Some preliminary interpretation of compressional wave velocities and depths to the indicated horizons has been accomplished for all shots recorded both on CHAIN and on DISCOVERY. During April Mr Stuart Crampin of the Department of Geodesy and Geophysics of Cambridge University has been working with Miss Bunce and Dr. Hersey on the final stages of interpreting the results of analyzing the first arrivals of the energy travelling by refraction paths below the bottom. Several structural interfaces have been identified between the ocean floor and a depth of twenty-three kilometers.

Compressional velocities vary from near-sea water values to about 7.6 km/sec. We plan to publish these results jointly with the Cambridge geophysicists.

Heat Flow Measurements at Sea (Mr. Reitzel).

J. Reitzel has written a doctoral thesis with the title "Studies of Heat Flow at Sea", which has been accepted by Harvard University. This thesis discusses the heat flow measurements made from R/V CHAIN in 1960, and also reviews all the published data on oceanic heat flow. One of the main conclusions is that averages of heat flow on continents and in the deep-sea basins differ by less than their standard errors. It is inferred from this near-equality that most of the heat flow is due to radioactive sources having equal strength under continents and oceans.

A new instrument, having outrigger probes on a small piston corer, has been designed and is nearly completed. Its purpose is to permit work in moderately bad weather, and to save ship time by eliminating the separate lowering of a corer. The speed and convenience of this instrument should make it practicable to do some detailed surveying of the heat-flow anomaly on the Mid-Atlantic Ridge, as is planned for this summer.

R/V ATLANTIS Cruise #260 (Dr. Pratt).

ATLANTIS Cruise #260 departed Woods Hole on 11 October 1960 and returned there on 7 November 1960. The main purpose of the cruise was to take a series of velocimeter lowerings southwest of Bermuda and secondarily to make geologic investigations of the continental slope and Muir Sea Mount.

Ten velocimeter lowerings, ten Edgerton camera lowerings, nine pipe dredge lowerings, and twenty-six Van Veen dredge lowerings were completed on the trip and detailed bathymetric surveys were made of Hydrographer Canyon, Muir Sea Mount and the south side of Plantagenet Bank. The data is largely analyzed and is being incorporated into various studies.

A cruise report on ATLANTIS Cruise #260 with an overall plot of the ship's track and stations was compiled by Richard Pratt and is to be published as a Woods Hole Technical Memorandum. Bathymetric charts have been prepared of Plantagenet Bank on a scale of two inches to the mile and overlay charts with the soundings corrected for both sound velocity and slope have been drawn up. The work on Plantagenet Bank is incorporated into Project ARTEMIS studies currently underway by WHOI and other institutions. Bathymetric charts of Hydrographer Canyon, the continental slope cross-section, and Muir Sea Mount are being made on a scale of one-half inch to the mile.

Developing and printing of the bottom photographs taken on ATLANTIS #260 was done by Richard Pratt and John Arend at WHOI. The pictures are remarkable for their clarity and the quantity and variety of marine organisms shown. The photographs have been exhibited at Woods Hole and the Massachusetts Institute of Technology and numerous prints have been distributed to various interested people. The scientific significance of the photographs taken on ATLANTIS #260 is that they were taken in conjunction with closely controlled bathymetric and dredging surveys, to give us a better understanding of nearby bottom features.

The sound velocimeter data was computed at Woods Hole for the ARTEMIS Project. The analysis of various dredge samples from the cruise is now nearly complete. The manganese-encrusted coral fragments from Muir Sea Mount are being analyzed by Hans Lowenstein at California Institute of Technology for paleo temperatures, and Donald Squires at the American Museum of Natural History has identified some of the coral species. Size analyses of the Van Veen samples from the continental slope were made by Richard Pratt.

Bathymetric Study of the Equatorial Mid-Atlantic Ridge (Miss Bunce and Mr. Parker)

The first part of this cruise was devoted to a topographic survey of the area of the Romanche Trench. The purpose was to chart the depth of water in this region in such a way as to determine the location and depth of the sill across the Mid-Atlantic Ridge which controls the flow of deep, cold water from the Western Atlantic into the Eastern Atlantic. The results have since been used to guide a hydrographic study designed to trace the flow across the sill.

Preliminary planning included plotting the available tracks and soundings in the regions including data from ALBATROSS, 1948, (Swedish Deep Sea Expedition), CRAWFORD 22 (WHOI, 1958) and VEMA 12 (Lamont Geological Observatory, 1957). The resultant chart was most helpful in deciding on the best plan for the bathymetric survey. We had planned to use anchored radio-acoustic buoys as aids to navigation, but it soon became evident that for sill depth determination in an area 600-800 miles long such a technique was impractical. Accordingly we used the familiar techniques of dead-reckoning controlled by celestial navigation, navigation by bathymetric control, and navigation by a gyro stabilized astronomical telescope under study by Dr. William Von Arx. Using these aids and an Edo UQN-1b with a PGR we studied the northeastern side of the Mid-Atlantic Ridge from just west of the Romanche Trench to a point somewhat over 600 miles to the east of it in the region of 10° west longitude. Midway of the region and bordering on the Guinea Basin a deep channel through the ridge was found. The minimum depth in the channel appears to be about 2000 fms. We expect to know much more of the bathymetry of the region as a result of continued study during the balance of CHAIN Cruise #17.

ACOUSTIC INSTRUMENTATION

Digital Computing Programs (Mrs. Hellwig).

The RECOMP II, a general purpose digital computer designed by the Autonetics Division of North America Aviation Inc., is being used for some acoustical problems. At present we are concerned with setting up a comprehensive program that will serve for large-scale reduction and analysis of data from various sources.

The programs completed to date fall mainly into the category of general utility routines which extend the basic capabilities of the computer. These include a "table-look-up" function, a versatile subroutine for interpolation, and a routine for automatic correction and counting of data prepared offline by the Versatape Off-line Paper Tape Punch. The Versatape unit is set up to produce punched paper tape, for direct input to the computer, in a special and somewhat restricted format. For collection and identification of large quantities of data, the established format presented serious limitations but these have been overcome by programming.

With respect to the programming of specific problems, a program for computation of sound velocities and corrected depths from sound velocimeter data has been completed. In progress are programs for: sound velocities in sub-bottom layers derived from seismic reflection data (the seismic profiler); a similar computation from seismic refraction data (explosive refraction profiles); volume back-scattering coefficients of deep scattering layers from explosive data; and bottom reverberation analysis of explosive data. The last two programs involve general-purpose routines for system response characteristics and explosive source spectrum characteristics. Still in the planning stage is a program for slope corrections to bathymetric data.

Aside from these specific problems, we are examining the possibility of using a digital computer on board ship which will operate continuously under control of a large scale data-processing program.

Arrangements have been made with Autonetics for leasing a Versatape unit for use on CHAIN. Leasing computer equipment for use on board ship presents special contract problems concerning maintenance, but hopefully these problems are being overcome. Hopefully this program would receive many different kinds of data-bathymetry, temperature, velocity, scattering, etc., and coordinate all of them with real time and navigational information. This would be valuable as data processing alone; given a computer of sufficient speed and versatility, considerable analysis (in the "real-time" sense) could be carried out simultaneously.

Ocean Bottom Photographs (Miss Broughton).

All pictures from CHAIN cruises 7 and 9 and ATLANTIS cruise 242 have been mounted on punch cards The pictures from ATLANTIS 260 have been started, with one lowering completed. At the end of this period there were 6706 mounted and punched cards in our files, or 11,486 mounted pictures distributed by cruise as shown:

A-242	1738 stereo pairs	567 single exposures
Ch-7	411 " "	235 " "
Ch-9	3768 " "	1269 " "
A-260	212 " "	26 " "
	4780 stereo pairs	1926 single exposures

This does not include some stereo pairs taken in various locations for Project ARTEMIS. These latter were mounted otherwise before the punched card file was instituted.

The printing of black and white pictures commercially has been carefully explored. One of the largest commercial photographers in Massachusetts was in process of attempting this at the beginning of the period. Though they made great effort we eventually came to the conclusion that it could not be done satisfactorily. The operation calls for handprinting. This is due to the fact that within a camera lowering the density of the film images vary to such a degree that, (1) a commercial automatic printing machine cannot compensate enough to give good resolution, (2) we have found grades 4 through 6 contrast paper must be used. Large volume commercial printers do not use paper of such high contrast.

We have found a small photographic firm which is willing and capable of carrying out a handprinting operation of this quality and magnitude. We have placed an experimental order of prints from three camera lowerings with this firm.

In February three staff members visited Edgerton, Germerhausen & Grier in Boston to be checked out on and to take delivery of the color inter-negative maker which EG&G designed and built for us to permit printing the color pictures from our bottom photography program.

The large volume of photographic material generated in this program has led us to set up an accounting system both for processing data and assuring their availability for scientific study. Cards have been designed and printed, and a filing system devised to account for bottom photographs, (i.e., what is the progress of specific lowerings, where films are located, how many prints there are and so on).

Spectrum Analyzer (Mr. Dimock).

A number of improvements have been made to this equipment during this period. For the most part these changes are to increase the versatility of the instrument. Some, however, are to correct defects found while using it last summer on the R/V CHAIN.

1. A new paper advance gear box has been installed to provide more dependable low speed operation.

2. New styli have been designed and tried experimentally. A production sample has been ordered from a commercial manufacturer for further testing. This is to correct a short life characteristic inherent in the original design.

3. A new timing system has been designed and is now being built. This will provide timing marks as before and in addition will encode the date and time once each second directly on the record.

4. A new set of filters has been purchased and a modulator-driver constructed. These filters extend the frequency coverage down to 15 cps. These are of 10 cps bandwidth and are spaced 8 cps apart.

Several ideas have been explored to develop a suitable level detector. These will be used to provide quantitative information about the input waveform.

Improvement of Echo Sounding by Pulse Envelope Coincidence Detection
(Dr. Graham and Mr. Hess).

In November 1960, during a part of BEAR Cruise #258 in the Tongue of the Ocean, the problem of improving the angular resolution of echo sounders was studied. It was expected that by means of a planar array of four hydrophones connected through appropriate pulse shaping circuits to a four-fold coincidence detector, it should be possible to sort out from complex echo patterns only those returns which had originated in a direction approximately perpendicular to the plane of the array. Unfortunately, a number of unforeseen experimental difficulties prevented any evaluation of this scheme and another series of experiments will have to be conducted with more suitable equipment. The occasion, nevertheless, provided an excellent opportunity to study the types of signals that originate from complex bottoms; these studies led to a better appreciation of the problems involved in improving the angular resolution of echo sounders

The group carrying out this research now favors (but for lack of experience, cannot yet recommend) the following scheme for improving conventional echo sounders. The bottom is insonified with the usual broad beam transducer operated so as to produce pulses about one millisecond long at 12 kc/s carrier frequency. The usual receiver is replaced by at least three (we have some reasons for preferring five) hydrophones arranged in a horizontal planar array some tens of feet across. The echo signals received in each of these channels, following appropriate amplification, are rectified, and by differentiation, clipping and possibly various other means are converted into a series of short pulses which now proxy for the original echo envelope These pulse trains are all connected to a coincidence detector which gives output only during the time that all the inputs are energized; this output is connected to the usual echo sounder recorder. Given this arrangement of circuits and hydrophones, those echoes will be recorded which reach all the hydrophones of the array simultaneously, i.e., from a direction normal to the plane of the array. Echoes originating from an inclined direction will not reach all hydrophones simultaneously, and the coincidence detector will discriminate against them strongly, especially if the individual proxy pulses of the echo envelope are short and the coincidence detector has fast resolving time. Even though in simple cases this system would provide, in effect, a narrow-aperture listening beam with no side lobes, we can predict that with various types of complex target geometry, (for examples, the deep scattering layers, and very rough bottom in very deep water), this system would be of limited benefit over the usual technique.

In anticipation that this scheme will often be useful when properly instrumented, we have been exploring the possibility of achieving, with an array of hydrophones fixed to the hull, a roll-stabilized and steerable listening beam through the use of a gyro stable vertical having servo outputs connected to an appropriate magnetic pulse variable delay drum The engineering problems are not formidible but the task of reducing the technique to practice is greater than we can assume at the present time, and we are attempting to locate a firm which will be able to construct major portions of the system We have hopes that the magnetic delay drum can be made sufficiently versatile that it will be useful, in addition, for studies of the directions of arrival of refracted seismic waves

Marine South African Seismic System (Dr. Graham and Mr. Hess).

During the past six months there has been satisfactory progress in our efforts to adapt the South African Seismic System to various use. We are especially pleased to remark that owing to the complete information that was generously given to us by our colleagues at the Bernard Price Institute for Geophysical Research at the University of the Witwatwersrand our vibrating sound source, patterned after their design, performed satisfactorily the first time it was energized. It has been operated several hours under various conditions and appears to be capable of delivering a force in the neighborhood of 500 lbs. on each vibration stroke in the frequency range 40 to 100 cps. We are now exploring the optimum conditions governing its operation: water pressure, gap width of oscillating valve, ballast capacity of water supply system and so on. This source has not been tested radiating into sea water, but only on land. It is our expectation that this sound source will be particularly useful for studying the problem of coupling low frequency sound signals into water for seismic purposes, and we expect to work with it extensively during the coming months for driving various types of radiators.

The development of electronics components for processing the reflected signals seems to be progressing well, but the adequacy of the total system as now visualized cannot be judged until it is tested as a whole These tests will begin soon and will proceed conveniently with the studies of the radiation problem.

Precision Time Source for Remote Control (Mr. Breslau).

A miniaturized precision time source for use in submerged instruments has been designed and constructed. This unit employs a 100 kc crystal as its frequency standard, a silicon transistor oscillator stage, a germanium transistor buffer stage, and five silicon induction transistors as decade frequency division stages.

The entire unit has been encapsulated inside a flexiglass cylinder 1 1/2" in diameter by 5 1/4" long and may be thought of as a 3 terminal black box. The input requirements are 20 to 30 volts dc at 3/4 watt. The output is a 100-volt positive signal at one second intervals. The frequency stability averages less than ten parts per million per degree centigrade as determined by the temperature coefficient of the present 100-kc crystal, which is operating without an oven. The point to point jitter is less than one part per million.

The frequency division circuitry is stable from 5°C to 35°C, which is considered adequate for general oceanic work. This temperature range could easily be extended if desired by using the same basic circuitry with a division base of less than one decade per stage.

Inquiries are presently being made for a 100-kc crystal which has a smaller temperature coefficient. If the present crystal were to be used with an oven it would provide a frequency stability of less than 10 parts per million over the entire operating temperature range. This would necessitate increasing the length of the cylinder by 2 1/2" and the input power requirement by about 10 watts.

The cost of components employed is less than one hundred dollars.

Telemetering Buoys (Mr. Dow).

Six telemetering buoys designed for acoustic listening were constructed by Concord Controls Inc. and WHOI personnel in a combined effort to provide R/V CHAIN with the units as navigation aids for operations in the Romanche Trench.

Four of these units received final testing in St. George's Harbor, Bermuda and were found satisfactory. Time did not permit complete assembly of the remaining two but it is understood that these were also made operational aboard ship during the cruise.

Inverted Echo Sounder (Mr. Dow).

The original model of the inverted echo sounder was improved and used successfully during two cruises in the Bermuda area in February and in March-April. When lowered with the Bureau of Standards velocimeter during February, precision depth measurements were obtained on a continuous record, simultaneously with the velocimeter information. Further use of the sounder for a detailed bottom survey in deep water was undertaken successfully in the later cruise,but unfortunately the gear was lost near the end of the operation when it was accidentally dragged on the bottom.

Meanwhile, however, a second and more compact version of the instrument had been completed at WHOI and was flown to Bermuda for deep water testing. Preliminary trials indicated satisfactory operation except for some low level transmitter-receiver cross-feed which is now being corrected. A modified version of this second instrument will soon be ready for reproduction by a commercial firm for general use.

Oceanographic Computer (Mr. Baxter).

Satisfactory operation of one eight-channel computer in all functions was achieved late in October. As the necessary modifications to each of the other computers were completed it was delivered by Mr. Maddux and set up and tested at the following laboratories on the following dates: MPL October 19, Lamont Geological Observatory November 16, Hudson Laboratories November 27, and Scripps Institution of Oceanography December 4. The remaining computer was retained at WHOI and used in ARTEMIS transmission correlation tests in February. A final technical report on the oceanographic computer is in preparation at WHOI and a final technical manual incorporating the last minute changes is in preparation at Electronic Associates.

APPENDIX

Use of Vessels

Operation of R/V CHAIN during this period was as follows:

Cruise No.	Departure Return	Work Area	Principal Investigations	Scientist in charge
13	27 June 1960 12 Nov. 1960	Northern European waters - Bermuda	Bathymetry, Thermistor chain obs., sound velocity measurements, bottom coring, dredging, bottom photography, hydrographic observations	J. B. Hersey
17	1 Feb. 1961 23 Mar 1961	Bermuda - Romanche Trench	"	E. Hays A. Voorhis

Operation of R/V ATLANTIS during this period was as follows:

260	11 Oct. 1960 7 Nov. 1960	Bermuda Eleuthera	Dredging, coring, velocimeter lowerings, camera lowerings, B. T.	R. H. Pratt

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